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THESIS

IMPLEMENTATION OF ELECTRONIC MAIL FOR INFORMAL NAVAL COMMUNICATIONS

by

Harold M. Yelton

March 1988

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Implementation of Electronic Mail for Informal Naval Communications

by

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Lieutenant, United States Navy
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of

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ABSTRACT

This study focuses on electronic mail and its applications for the transfer of informal information within the Department of the Navy. Discussion of the Defense Data Network as an evolutionary development in data switching technology is provided for historical perspective. The utility of electronic mail media is evaluated with an emphasis on the human interface. A brief synopsis of electronic mail cost compared with other message delivery media (telephone, postal mail, and AUTODIN) is provided. The technical aspects of electronic mail involving local area networks, the Base Information Transfer System (BITS), and AUTODIN are provided to demonstrate the feasibility of implementing an electronic mail system.

TABLE OF CONTENTS

I. INTRODUCTION

A. BACKGROUND

Communication is generally understood to be the act of imparting or exchanging information, knowledge, and ideas. Today the limitations of both distance and time have been removed, and almost instantaneous communication over any distance on the earth is now available.

To facilitate communications some medium is necessary. Media may be divided into two categories: real-time media and record media. Real-time media deliver information as it is produced, and record media present information in a finite time, and also can preserve it. With computer-mediated communication, information can be transported in real-time media and preserved by record media. [Ref. 1: p. 5]

In any organization there is a continuing need to function more efficiently. Computer-mediated telecommunications possess the ability to transport information instantly to any location. This information can, within the same transaction, be processed and acted upon.

Computer-mediated telecommunication within the Navy is largely influenced by Department of Defense (DoD) and Department of the Navy (DoN) policies, not by technological developments in the computing industries. Policy choices significantly influence the direction and speed of communication changes, as well as applications and characteristics of the information that are generated using this technology. To date, computing industries have operated in an extremely dynamic market characterized by continuous technological improvement and market expansion. To the degree this technology can save manpower and speed operations, it will increase productivity. The degree to which the Navy exploits this technology will be a function of the Navy's current communications media and policies. [Ref. 2: p. 78]

B. GOALS AND OBJECTIVES

The purpose ot this study is to explore and to discuss the value of electronic mail for Naval communication systems. In order to achieve this goal, several objectives must be be met. These can be summerized as follows.

1. Evaluation of existing and potential communications techniques must be considered, including how to determine the efficiency and effectiveness of electronic mail, and whether it can meet the Navy's future needs.
2. Organizational changes resulting from electronic mail should be examined, including the effect of new technology on the way the Navy does business, its effects on the flow of information, and its impact on Navy personnel and on organizational structures. The ability of the Navy to accept change also must be determined, as must be who will take the initivative if change is to occur.
3. The topic of communications should be examined, including the current means of informal communication for the DoN, communication effectiveness and problems, and the effect of communications changes on Navy personnel.
4. Specific costing data should be compared and contrasted to give insight into what informal communications currently cost the Navy, and to uncover possible cost saving alternatives.
5. Technical aspects of electronic mail must be be considered, including present and anticiped communications equipment, interfacing new equipment with the current systems, anticipated costs and savings, and the ability of electronic mail mail systems to change with future design changes.

C. THESIS SCOPE

This study primarily focuses on electronic mail and its applications for the transfer of informal information within the DoN. Information of a purely operational nature or involving command and control is not discussed because it does not relate to electronic mail as a medium of informal message transfer.

Chapter II provides background information on three basic kinds of communication networks for historical perspective, along with a brief overview of the Defense Data Network (DDN). The discussion

includes general concepts of systems operations, in order to provide basic understanding, show evolutionary development of switching technology, and to enhance further discussion in subsequent chapters.

In Chapter III the benefits and problems of interfacing with electronic mail are looked at from a social (versus a technical) level. The utility of electronic mail media is also discussed.

Chapter IV compares and contrasts cost of electronic mail with that of record message traffic (AUTODIN), postal mail service, and the telephone. An examination of commerical electronic mail systems is provided to highlight the vast potential electronic mail offers for saving money while increasing efficiency.

Chapter V examines the technical interface necessary to implement electronic mail fully into the Navy's communication scheme. Current Navy plans to use the Base Information Transfer System (BITS) are explained as they relate to DDN, local area networks (LANS), and electronic mail. A synopsis of the U.S. Army's plan for eventual migration of all message traffic, both formal and informal, is provided.

Chapter VI provides conclusions and recommendations based on this study.

II. COMMUNICATION SYSTEMS AND THE DEFENSE DATA NETWORK

There are several types of communication networks. They are characterized by the hardware and functional operations performed to accomplish communications between users. For the purposes of this thesis only three will be discussed. They are:

1. Circuit-switched networks
2. Message-switched networks
3. Packet-switched networks. [Ref. 3: P.12]

A. CIRCUIT SWITCHING NETWORKS

In circuit switching, a "copper" path (wire) is established using dedicated circuits between users. These circuits are allocated to the users until a given information transfer is terminated. [Ref. 4: P. 27]

1. Advantages of Circuit Switching

a. An extremly well understood and developed technology that has many useful applications. circuit switching is used with voice-based common user telephone systems. The Automatic Voice Network (AUTOVON) is a good example of a circuit-switched network. AUTOVON is a direct interconnected telephone network between military and other government installations. It provides direct dialing service to support essential operations, intelligence, logistics, and administrative functions worldwide. [Ref. 5: p.14]

b. Calling procedures are the same for data and voice connections. Circuit switching is a very simple operation. Once the circuit is established, no protocols are required for the network switching function, so the data will pass through in a transparent manner. [Ref. 4: p. 33]

c. Circuit switching is most efficient when transmitting large quantities of data. [Ref. 6: p. 70]

2. Disadvantages of Circuit Switching Networks

a. Terminal equipment at each end of a connection must be compatible. When a computer is used, each line (circuit) must have the same characteristics as the terminals at both ends, since the switching operation is essentially not using protocols.

b. Messages entering a circuit-switched network are subject to blocking, i.e., receiving a busy signal.

c. Circuit switching is relatively inefficient. Once a circuit is established the entire bandwidth is reserved for the exclusive use of that one transaction, whether it is needed or not.

d. Since a network resource is dedicated on an exclusive use basis there is a call setup delay and the possibility of blocking (busy signal) within the switches or communication lines.

B. MESSAGE SWITCHING NETWORKS

In message switching a dedicated path between the source and the destination is not required to route messages. Transmission of data is accomplished through what is called "store and forward" routing techniques. Messages are received and stored in their entirety at each intervening switching node before they are transmitted to the next node. Messages may be of variable length. There is a certain amount of overhead time spent at each node, consisting of normal processing time (based on length of message) and possible delay time (due to being held in queue). The emphasis in a message-switched system is on reliable delivery of each message, even at the cost of delay. This is both its strength and its weakness.

In message-switched networks, the time it takes to service or process a message is a function of the length of the message. Processing time consists of time needed for reading the header for address information and for error checking header and message contents. A message to be sent has destination information attached to it. After it enters the network it is passed from node to node based on the destination address.

Automatic Digital Network (AUTODIN) is an example of a message-switched network. Navy message data are currently processed through the AUTODIN system via the Local Digital Message

Exchange (LDMX) in the local base Navy Telecommunications Center (NTCC) or through Navy Communications Processing and routing Systems (NAVCOMPARS). Messages handled by the Naval Telecommunications System (NTS) or AUTODIN are referred to as record message traffic.

1. Advantages of Message Switching Networks

a. The sender and receiver do not have to be available simultaneously.

b. Priorities can be assigned to messages to establish speed of service and servicing rules. Table 2.1 [from Ref. 7] illustrates the priorities used in the AUTODIN system.

c. Message-switched networks have error checking and recovery procedures for all data transiting the network. Transmission between one switch and another is provided with error control. Incoming messages are not only held for immediate access but are also transfered to a magnetic disk backup.

d. Messages are numbered and receipt and delivery times recorded and filed. A log is kept of all messages passing through a switch so problems of non-delivery can be traced.

e. The blocking of messages that can occur with circuit switching when the system is under heavy load (i.e., a busy signal on AUTOVON) will not occur with message switching. Rather, if all channels to the next node are unavailable (whether due to system failure or network overload) the message is placed in queue where it will stay until transmission can be accomplished. [Ref. 3: p 13]

f. High bandwidth efficiency and channel utilization are possible.

Table1

SPEED OF SERVICE/SERVICING RULES FOR AUTODIN

PRECEDENCE LEVEL	PROSIGN	OBJECTIVES
FLASH	Z	As fast as possible (less than 10 minutes)
IMMEDIATE	O	30 minutes
PRIORTY	P	180 minutes (3 hours)
ROUTINE	R	360 minutes (6 hours)

2. Disadvantages of Message Switching Networks

a. Large variances in delay time can be expected. This is because processing time is a function of message length and entire messages must be stored at at each switch (possibly indefinitely) creating long queues. The delay could range from a few seconds to several hours or even days. With AUTODIN this delay can be extensive depending on speed-of-service requirements mandated by the precedence level assigned to the message (see Table 1 above).

b. Poor response times are possible for interactive traffic.

c. Each switch requires powerful processors and large storage capacity. [REF. 8 : p. 34]

C. PACKET SWITCHING NETWORKS

Packet switching is simply message switching where the maximum message length is limited. These limited-size messages are called packets. Packet switching involves the quantization of information into discrete packets. Each packet than is treated as though it were an individual message, and contains complete source and destination address information. Typical packet length is from 1000 to a few thousand bits. On DDN, the fixed packet length is 1224 bits, of which 1008 bits are actual data and 216 bits are system overhead, as shown in Figure 2.1 (from Ref.10).

Packets move around the network on a hold and forward basis, similar to mesage switching. That is, each packet is individually dynamically routed through the network instead of using predetermined routing. A receiving packet switching node (PSN) holds a copy of a packet until it is processed and checked for errors. After sucessful delivery of the packet to the next switch, the copy in memory is destroyed.

Since all messages are broken down into similar size packets, both long and short messages can move through the network with minimum delay and interference. It is possible that each packet will take a different route through the network. The data are then reassembled into the original sequence of packets at the destination, using packet assembly devices. The destination user then transmits an acknowledgement message back to the source to confirm receipt of the entire message. [Ref. 9: p. 21]

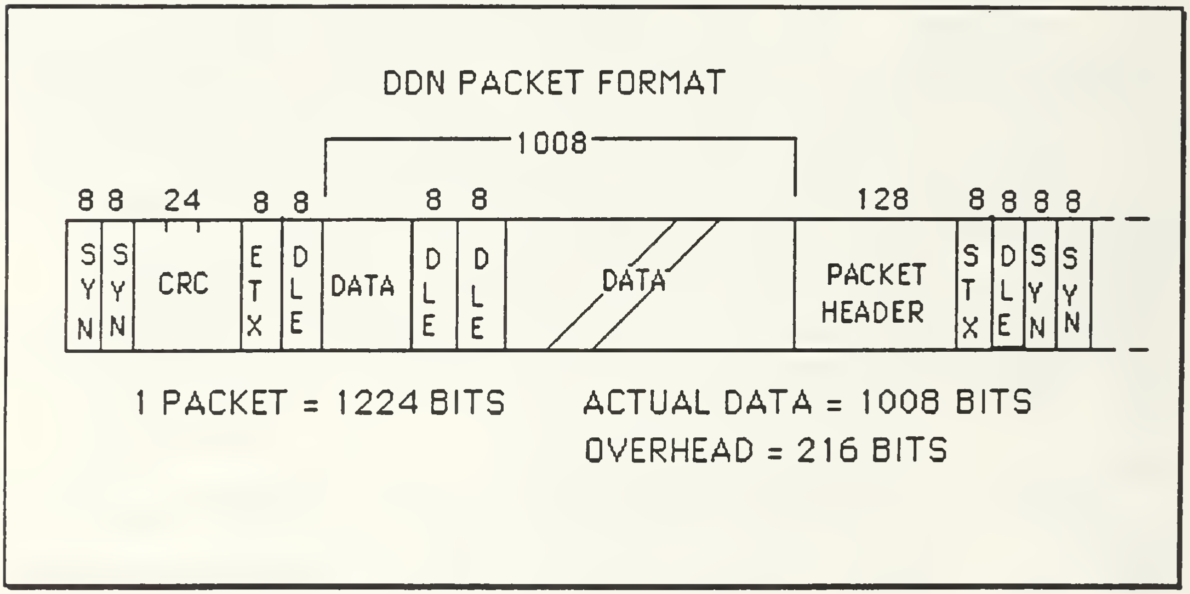

Figure 2.1 DDN Typical Data Packet

The concept behind packet switching is to combine the advantages of message and circuit switching while minimizing the disadvantages of both. On the surface, packet switching would appear to have little advantage over message switching. However, just limiting the maximum size of the data packet can have a

dramatic effect on performance. There are two approaches to transmitting messages over a packet-switched network. The two approaches are called datagram and virtual circuit,

In the datagram approach, each packet (called a datagram) is treated independently, just as each message is treated independently in a message-switched network. Each datagram may follow a separate route to its utimate destination. The route selected depends on queue length at each intermediate node.

In the virtual circuit approach, a logical (versus physical) connection is established before any packets are sent. A logical connection establishes a designated route between sender and receiver prior to data transfer. Each node on the established route knows where it will send each packet. Virtual circuits provide an advantage when a user has a high volume of traffic to transmit over an extended period of time. Otherwise, when only a few packets are required for transmission, datagram service is faster. Datagram service is also more flexible and more survivable because of the dynamic routing capability of datagram service. When a switching node fails for some reason, packets are automatically routed to other nodes. [Ref. 6: p. 34]

1. Advantages of Packet Switching Networks

a. Packet-switched networks can provide formating and speed conversions between unlike terminal devices.

b. Packet-switched networks are essentially nonblocking because of store and forward message processing capability.

c. Packet-switched networks achieve very high efficiency and line utilization. Since variable sized messages are broken down into fixed packet lengths, long messages and short messages do not interfere with each other as they do in message-switched networks.

d. Operations are nearly real time due to the dynamic routing scheme resulting in minimum delay. [Ref. 4: p.35]

2. Disadvantages of Packet Switching Networks

a. To achieve flexibility and survivability, many packet switching nodes must be employed.

b. Complex routing and control procedures are required, creating more network overhead. [Ref. 4: p. 36]

D. DEFENSE DATA NETWORK

1. Background

The DoD currently utilizes the DDN computer-mediated communication system to transmit data. Roots of the DDN system go back to the development of the first packet-switched network, the Avanced Research Projects Agency Network (ARPANET) in 1969. At the time the military needed some way to share sophisticated computer resources (both hardware and software) and to run specialized applications. Acquiring and maintaining individual systems at all locations would be costly and inefficient. The concept of a distributed network was developed to interconnect various individual systems.

The concept soon expanded beyond its original experimental nature into a network that served operational purposes. ARPANET provided users access to the network, provided they had a terminal, modem, host computer, and phone line. The resources of the network were made available to military computer terminal users, permitting wide spread general-purpose communications.

The development of the DDN actually began in 1981. At the time the Defense Communications Agency (DCA) was tasked with developing an ARPANET-based packet-switching network to replace AUTODIN. The original replacement was to have been a similar communications system called AUTODIN II. [Ref. 9: p. 63] However, DCA settled on the concept of packet switching in April 1982, due to its efficiency and economy. In March 1983 the Office of the Secretary of Defense issued a policy statement:

> All DoD ADP systems and data networks requiring data communications services will be provided long-haul and area communications, interconnectivity, and the capability for interoperability by DDN. Existing systems, systems being expanded and upgraded, and new ADP systems or data networks will become DDN subscribers.... [Ref. 10: p. 1]

The ARPANET was divided into two separate networks in 1983, MILNET and ARPANET, which have evolved into the unclassified

segment of the DDN. The DDN now is in the process of becoming a fully integrated network incorporating both unclassified and classified communications. The classified network consists of the following networks: the Strategic Air Command Digital Network (SACDIN), the DoD Intelligence Information System (DODIIS), and the WIN Communication System (WINCS). Figure 2.2 [from Ref. 11: p. 3] illustrates this development. Access to the large bandwidth of the unclassified network will be provided to all users via a one way gate. The National Security Agency is developing technology called BLACKER which will allow the DDN to be fully integrated into a single, shared, multilevel secure network. [Ref. 10: pp. 2-3]

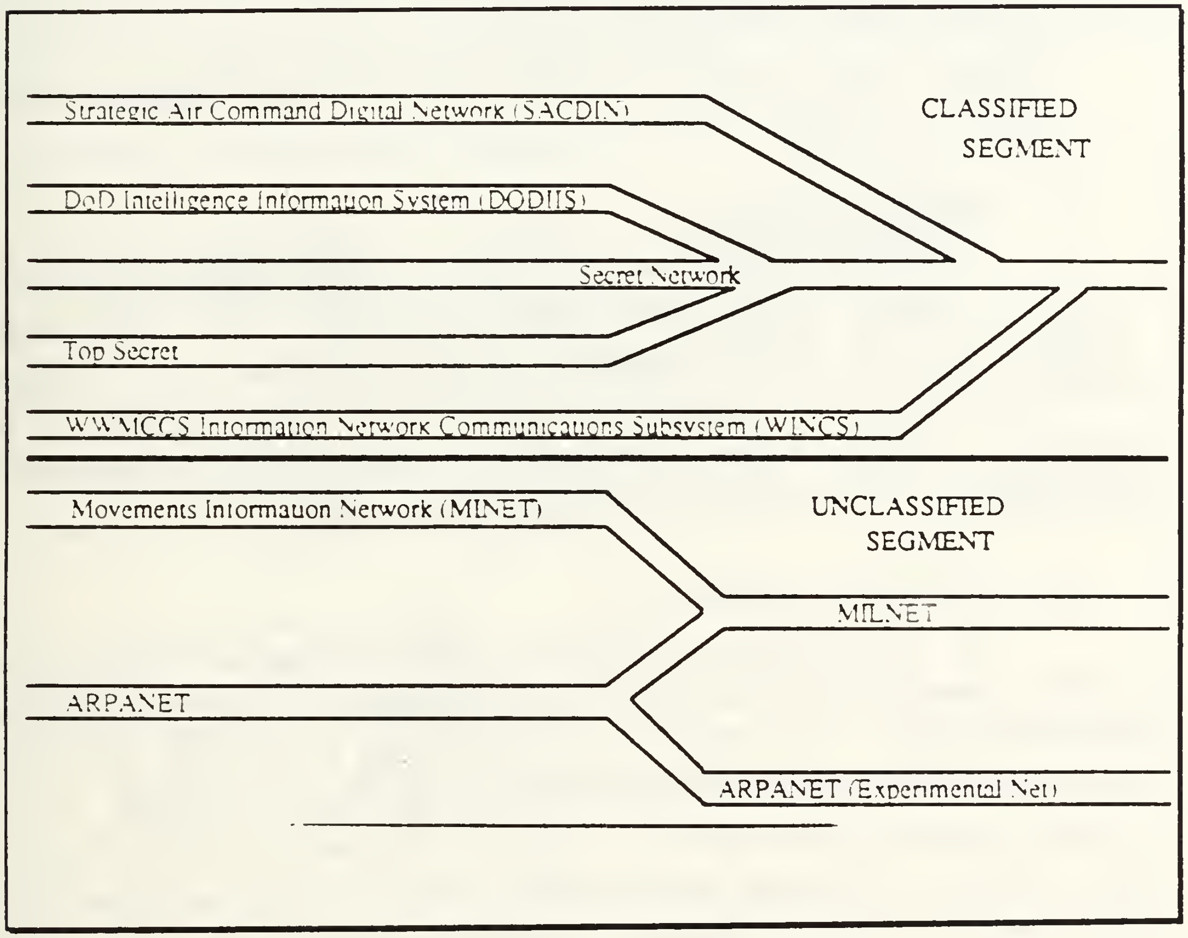

Figure 2.2 DDN Evolution 1982 To Present

The general DoD objectives for DDN can be summarized as:

1. Implement a common-user telecommunications network for DoD.
2. Provide high-speed, reliable, survivable communications.
3. Standardize telecommunications protocols.
4. Minimize dedicated networks.

The objectives of the Navy DDN program can be summarized as:

1. Provide Navy subscribers with improved data communications capability.
2. Provide Navy subscribers with highly survivable and reliable means of connectivity with other DDN users.
3. Reduce Navy communications costs.
4. Reduce Navy software development and maintenance costs. [Ref.12: pp.1-2]

2. DDN Technology

The DDN connects network resources and users regardless of location through data transmission switches. The transmission technique for the DDN is packet switching, as previously described. DDN technology can be categorized in two functional areas: (1) the backbone network, which comprises the packet switches and trunk lines, and (2) the access network (see Figure 2.3).

a. Backbone Network

The DDN currently uses the C/30E packet-switch computer system, developed by the BBN Communications Corporation, as the backbone PSNs. The C/30E is being upgraded to a C/300, which will provide improved performance and a significant increase in the number of access ports [Ref. 8: p. 46]. The original 1982 DDN Program Plan included 171 PSNs serving 488 hosts and 1446 terminals. The DDN has now grown to several hundred switches serving over 1000 hosts and many thousands of terminals. Trunk lines connecting the PSNs are capable of operating at speeds from 9600 bps to 56000 bps. [Ref. 11: p.5]

b. Access Network

The access network consists of host computers and other equipment used to connect users to the backbone network. Host computers are connected to the DDN using specific interface protocols, either X.25 or ARPANET 1822. Host computers can access the network either directly or through a Host Front End Processor (HFEP). Terminals may be connected to the network through a Terminal Access Controller (TAC), either directly (hard-wired) or indirectly via a modem and phone line. Terminals also may be connected to the DDN individually through a host which is itself connected to the network. Figure 2.3 [from Ref. 11: p. 4] illustrates this architecture. Direct TAC access connections can handle rates of 9600 bits per second (bps), while dial-up lines can operate at rates of up to 2400 bps. [Ref. 11: p. 4]

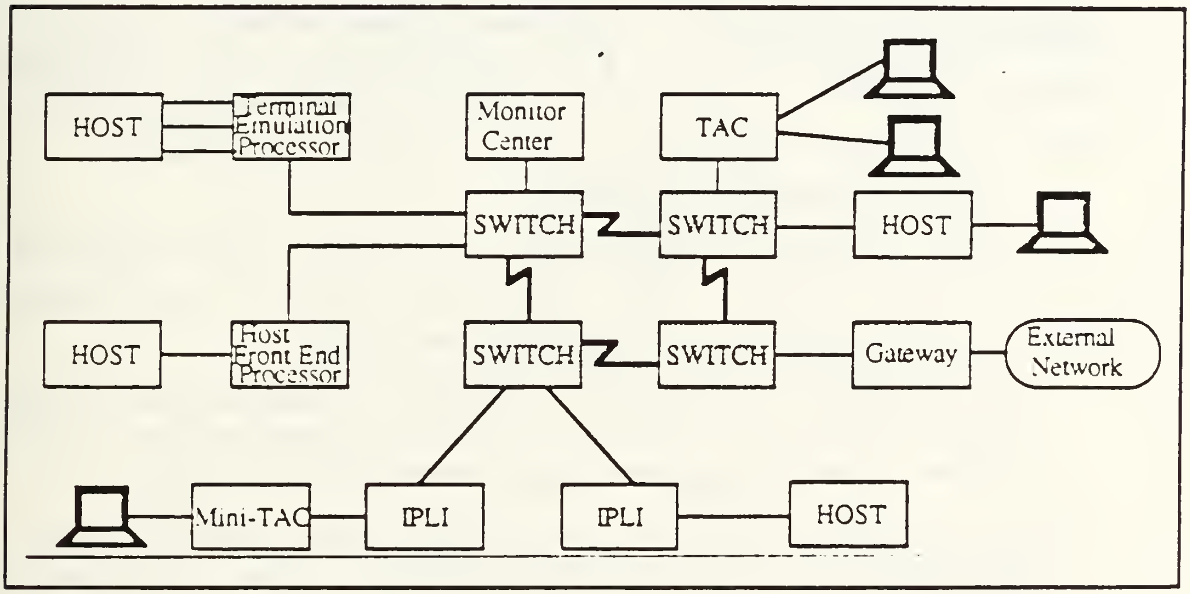

Figure 2.3 DDN Backbone And Access Components

3. DDN Performance

The network is designed to minimize delay, detect errors, ensure proper delivery of packets, and maximize availability of services. Processing time for a packet accounts for only a small portion of the response time. The response time for an interactive user is only about 200 milliseconds more than that of interactive systems with dedicated long-haul circuits. The average end-to-end delay for a high priority packet is only about 90 milliseconds, with 99 percent of all packets being delivered within one-half second. [Ref. 11: p. 5]

The chance of an error being transmitted on DDN and not detected is extremly small. The undetected error rate is 4.2×10^{-18} or less [Ref. 11: p.5].

DDN is also designed to use preemption and precedence routing (similar to AUTODIN) when network resources are critically needed. Four precedence levels are used to prioritize traffic as it enters the network. In times of national crisis message traffic of higher precedence will preempt traffic of lower precedence.

4. DDN Standard Protocols

DDN standard protocols are used by the host computers to achieve interoperability. The applicable protocols are shown in Figure 2.4 [from Ref 11: p. 9] and described below.

1. DoD standard Transmission Control Protocol/Internet Protocol (TCP/IP) allows end-to-end flow of data between two computer systems or between a host system and TAC.
2. Telnet protocol converts data traffic from different types of terminals to a common virtual terminal format throughout the network.
3. File Transfer Protocol (FTP) allows for transfer of files between computer systems.
4. Simple Mail Transfer Protocol (SMTP) allows for the transfer of electronic mail between DDN hosts and between the DDN and other compatible networks.

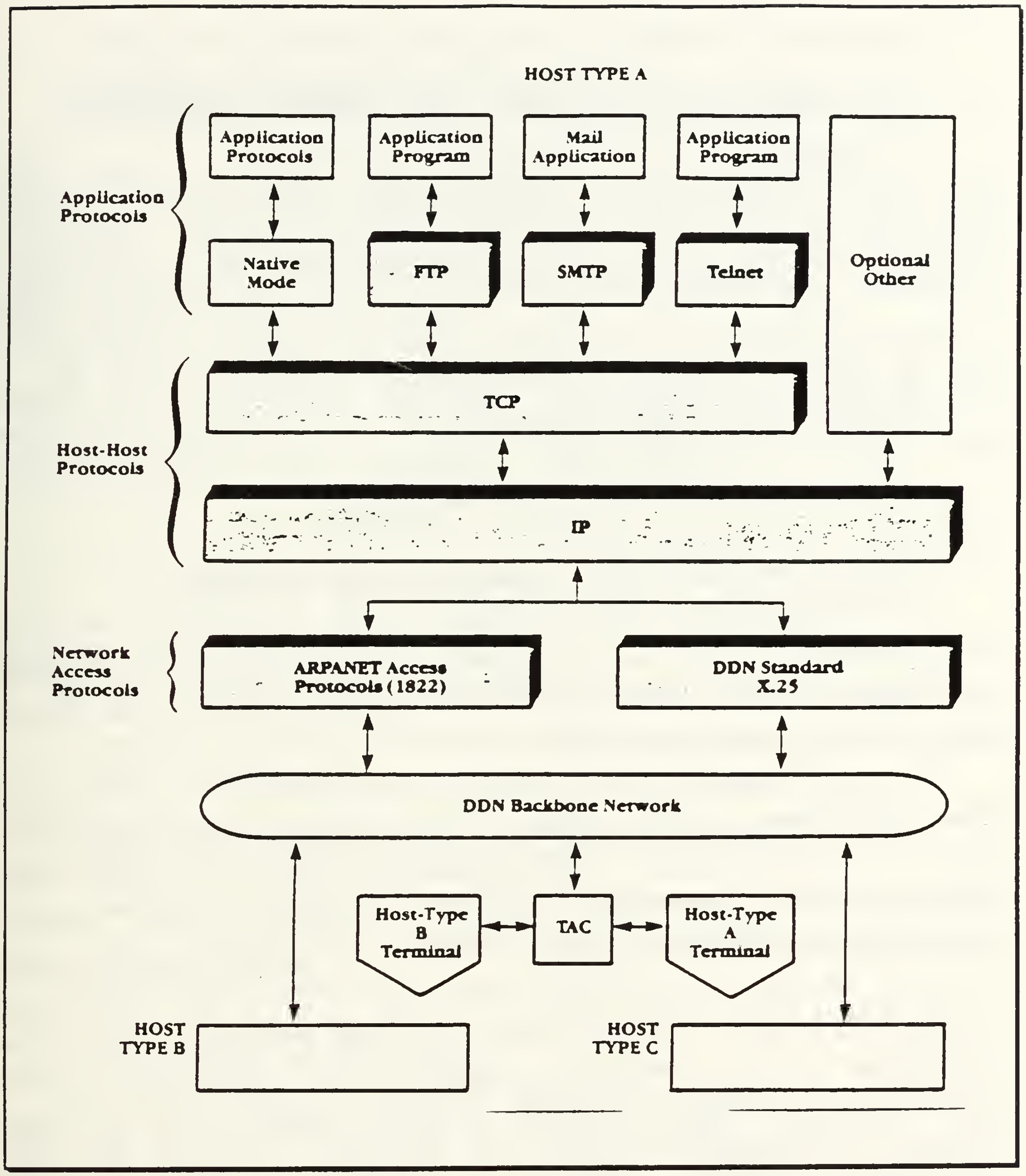

Figure 2.4 DDN Protocols Used For System Interoperabilty

III. ELECTRONIC MAIL: THE HUMAN INTERFACE

The evolutionary development of the microprocessor has given rise to rapid change in such technologies as word processers, personal computers, and large individually accessed communication networks. The greatest change has occured as these technologies have converged with telecommunication systems, allowing the linking together of previously independent products and the sharing of resources. This chapter discusses some of the human factors that are part of operating and interfacing with a relatively new communication scheme, electronic messaging.

A. COMPUTER-MEDIATED COMMUNICATION SYSTEMS

As communication options expand, users must decide which of their interactions will be conducted through electronic messaging, and which through more conventional channels like the telephone, mail, or Naval message traffic.

Computer-mediated communications use computers to structure, store, and process communications. Users compose text at terminals linked to a host computer, either directly or remotely by phone lines. The usual form of connection medium is a packet-switched network. Geographically dispersed groups are able to communicate at a speed and cost superior to telephone, mail, and often even face-to-face meetings. Messages may be sent to a single addressee, to multiple addressees, or to a predefined group. In some systems there is the option of using either a regular personal name, or a controlled personal identification number for message releasing authority. Confirmation of the time and date of delivery is usually provided to the sender. Many systems also include searching and retrieving, merging text, delayed transmissions, alarms, reminder files, and calendars. [Ref.13: pp. 3-4]

All computer-mediated communication systems have certain characteristics in common. The most fundamental, in terms of their effects upon human interaction, are:

* Communication takes place in written form.

* Sending and receiving may occur at different times because the computer stores the text. [Ref. 13: P. 15]

Communication via the written word has been shown to be very effective for transmitting factual information because of its precision and greater comprehension. A study done in 1971 that compared face-to-face, telephone, and teletype for the communication of factual information found teletype to to be the more effective mode. [Ref. 14]

Users are able to exchange far more information in a given time period than would be possible using conventional media. The individual's capacity for physical processing of information is greatly expanded, thus helping prevent information overload.

A system's impact on an organization can be defined in terms of outcomes, effects, and consequences. Impacts must be predicted in order to minimize or avert negative outcomes and to maximize positive ones. [Ref. 15: p. 120]

At the individual level, some basic assumptions can be made:

* Computer-based communication systems create new perceived needs for information.
* Communication often occurs better through the written word than through audio and visual media.
* Users may be able to deal with larger amounts of information more efficiently, when using computer mediated communications.
* If the need to communicate is strong enough, then a way to communicate will be found.

With easy access to network resources, geographic distance and time are removed as barriers to direct interaction. Access to other users and database resources is almost limitless. It has been observed that these systems are likely to change the patterns of communication within organizations, since the total amount of communication and the average number of persons with whom each user maintains regular communication are likely to increase. [Ref. 15: p.135]

In summary, by enhancing the ability to obtain, process, store, and disseminate information, a more efficient form of communications is encouraged and may result.

B. NAVAL TELECOMMUNICATIONS SYSTEMS INTERFACES

The mission of the Naval Telecommunications System (NTS) is to provide and maintain reliable, secure, and rapid telecommunications based on war time requirements to meet Naval command and control needs, to ease Naval administration, and to satisfy the Joint Chiefs of Staff approved requirements [Ref.16: p. 3]. The NTS is only partially able to fullfil this mission, since it is unable to keep up with demand, using the technology in place. Often communications are not rapid or reliable, which may hinder administration rather than ease it.

Naval telecommunications is a term that encompasses the entire communications effort of the Department of the Navy [Ref. 5: p.14]. Man-machine interfacing and interoperability of the various communication systems and subsystems often do not receive proper attention. When there is a perceived communication need, a system may be conceived, developed, and procured, before the interfacing issues are seriously evaluated. Rarely does the human factor enter into the evaluation process.

C. TYPES OF COMMUNICATION

1. Formal Communication

Formal communications in the Navy are explicitly recognized as "offical" communications. The formal communication network transmits standing operating procedures, formal orders and directives, periodic reports, offical correspondence, and so on. Formal messages make certain actions, decisions, or policies "legal" within the framework of the Navy. Formal communication channels are normally vertical, following the lines of the chain of command structure. The Navy relies heavily on a formal communication structure. However, formal channels do not always include all the important communications channels in a organization, and may even restrict the flow of needed information.

The Navy record message system is an excellent example of occassional information impediment. Because of the predilection for absolute accountability, only the commanding officer or those with designated releasing authority can release a naval message, no matter what the classification or content may be. The intent of the originator may be lost through editing and translations. Informal channels are sometimes created to circumvent the formal command structure.

2. Informal Communications

Informal communication channels are used to transmit information arising from the informal authority structure. Informal channels develop whenever there is a need to communicate, but access to the formal channels is unavailable or inappropriate. Informal channels are of two types: information that flows along formal communication channels but is not formal, and information that flows only on informal channels. The vast majority of all communications is informal. Informal communication tends to move horizontially while formal communications move vertically. Differences in status and rank can be ignored, allowing much freer and more open communication. The transfer of information can thus be more exact and candid, allowing "true" communication to take place. When operating under stress and uncertainty, organizations tend to resort to informal channels for information [Ref. 17: pp. 113-114].

In spite of attempts to reduce paperwork and message traffic in the Navy, there has been a constant increase in information flow. There exists a need, be it actual or perceived, for a great deal of communication. Computer-mediated communications is an extremely useful tool for managing such information flow.

D. ELECTRONIC MAIL

One of many applications available on DDN is the ability to provide electronic mail service. Electronic mail on DDN can serve most of the non real-time informal message needs of the Navy. It has several advantages over postal mail and the telephone, since delivery is made at electronic speed, no one needs to be there to

answer, and the message won't be blocked, and over Naval messages (AUTODIN) since it is informal and thus not restricted by formal protocols. A DDN user can compose messages as desired, using the text editing capability of a personal computer word processor or an editor provided by a DDN host computer.

Access to DDN can be local (direct) or remote (phone-modem). The message (mail) is then sent through the network and posted in the final destination mailbox. The designated mailbox can then be accessed and the mail read on screen or a printed copy made and physically placed in a mailbox. Figure 3.1 shows one conceptual layout of possible electronic mail components. [Ref. 9: p. 45]

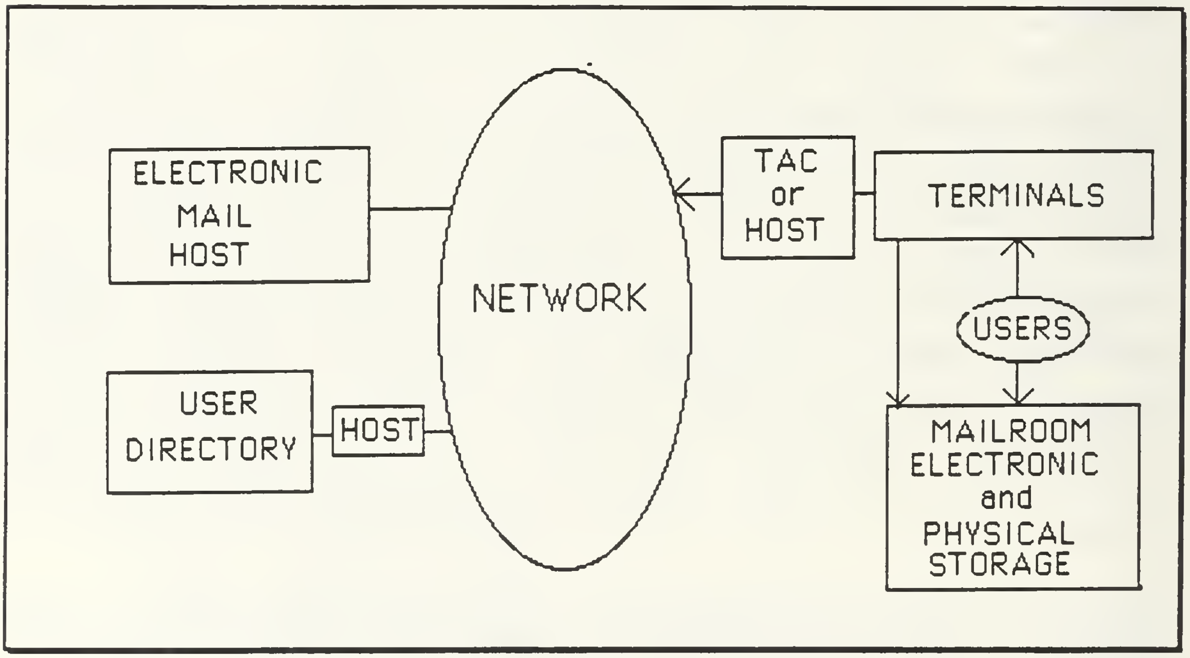

Figure 3.1 Electronic Mail Components

E. ELECTRONIC MAIL USER INTERACTION

In evaluating computer mediated communications the user usually is not interested in the physical aspects of a network, but rather in the services offered. Users expect these services to be useful and easy to access, that is, to have utility.

Decision makers use the concept of utility in arriving at choices among things that have no obvious "lowest common denominator." In other words, utility ratings are assigned to the results of possible acts, in order to select the one that yields the most total utility. Thus, the goal is to maximize utility.

Assuming that people tend to maximize utility is extremely useful in predicting behavior. If the price of or time required for a particular thing goes up in relation to prices or time required for similar things, people will tend to use less of the higher-priced objects and will substitute others for it. Conversely, if the price of a valued commodity goes down, people will tend to use more of it, substituting it for other things unchanged in price. [Ref. 18: pp. 81-82]

For maximum utility, the services offered by computer-mediated communications must be carefully tailored to user requirements. This includes careful design of interfaces. Essentially three interface possibilities are available for electronic mail preparation, reading, and storage: question and answer formats, menus, and screens for form filing. Question and answer formats may be used where the range of answers is either obvious or known to the trained operator. With menus a user is provided with a short list of possibilities from which he chooses one or many. Form filling is analogous to filling out paper forms, that is, it is using a computer terminal to fill in a form on a display [Ref. 6: P.14].

Rapid transport of electronic messages is not very useful if it is not fully integrated with word processing capabilities. For maximum efficiency, message composing, filing, transmission, logging, delivery, and reply must follow rapidly without unnessary key-punching. Electronic mail is more than just a means of transmitting text; it provides the opportunity for meaningful interaction between people who are not co-located. Messages can move quickly to various people who may be required to read or approve them. If sensitivity or security is an issue then only authenticated approved users may be allowed access to that message. In fact, circulating electronic messsages has been shown to be just as effective as paper messages and more secure. [Ref. 6: p. 33]

1. Benefits of Electronic Mail

Obtaining the predicted benefits of any computer-based information system has proven difficult. The history of computing is replete with examples of the extravagant claims about a new technology which could not be realized. [Ref. 14: p. 2]

Nonetheless, certain benefits of electronic mail appear to have been realized:

* Faster communications.
* Reduced communication cost (see Chapter IV).
* Increased productivity by savings in time.
* Reduced number of personnel dedicated to communications. [Ref.19 : pp. 3-8]

2. Problems of Electronic Mail

The problems associated with electronic mail are typical of problems that are encountered with any computer system:

* Different types of users, with varying skills and needs, must be accommodated.
* Decisions must be made concerning who should be given accounts and allowed access. [Ref. 19: pp. 3-8]

F. IMPLICATIONS OF ELECTRONIC MAIL TECHNOLOGY

Electronic mail technology is important for several reasons:

* Electronic mail systems are gaining acceptance in a large number of organizations.
* The attributes of electronic mail hold important implications for the human communication process in organization.
* Electronic mail can have a major impact on organizational communication processes.

Many major commercial enterprises throughout the world either plan to or now employ some form of electronic mail. Seeking to increase productivity among employees, these companies have discovered that ease of manipulating and communicating information is vital. [Ref. 19: p. 2]

The ability of a computer mail system allows people to send and receive their messages when convenient. Generally people do not

interact via electronic mail in real time. The communication is asychronous, allowing much flexibility. This ability has been refered to as the answer to "telephone tag", since people are not bound by their schedules. A user can send correspondence no matter what the time, and still be certain that the message will be delivered. The recipient of electronic mail can access his mailbox at his convenience and read the mail on the screen or get a "hard" copy for later reference. If a response is desired the mail can be answered immediately, or it can be typed typed and saved for later transmittal, i.e., at off-peak hours.

The primary impact here is one of increased productivity. Very little time is wasted trying to reach people by telephone, or waiting the several days for the mail to get through. Electronic mail allows people to communicate outside the normal workday, and across several time zones. In the commercial world this has resulted in shifts in normal working patterns. Accuracy of communication is enhanced due to the elimination of time constraints, blocking (delay), and distractions. [Ref. 19: p. 5]

Increased geographic dispersion and greater lateral communication on various projects are potential outcomes of the implementation of electronic mail. Electronic mail can be both an interpersonal and a group communication medium. Messages can be sent privately to one or a few persons, or broadcast to a large number of recipients. Many systems allow for distribution lists whereby a list of people can be given some name reflecting the nature of the affiliation, and messages can be addressed to the distribution list. [Ref. 19: pp. 5-6]

IV. COST/BENEFIT ANALYSIS

A. BACKGROUND

The concept of cost for the layman is a very simple matter: the cost of anything is simply the money that has to be paid for it. However, from an economist's point of view, the cost of anything is the value of what has to be given up to obtain it. What the money could have bought has been sacrificed. Additionally, cost is not always directly related to an outlay of dollars. Time and effort spent doing one thing means that same time and effort cannot be used doing something else.

The Navy currently spends a considerable amount on communication systems. Total annual recurring cost for all Navy Communications for FY 87 was approximately $472,000,000. Included in this amount is an AUTOVON cost of $65,802,000, an AUTODIN cost of $18,694,00, and a DDN cost of $19,089,000. The DDN leased circuit costs are expected to average approximately $28,500,00 per year from FY 88 through FY 90. These costs include only leased circuit and transmission costs. [Ref. 20]

These amounts, though quite substantial, could be misleading. What is important is the real cost to the Navy of user-to-user communications including the following communications systems:

1. Telephone--(AUTOVON, Wide Area Telephone System (WATS), direct dial long distance, local service)
2. AUTODIN/NTS--(message record communications)
3. Mail--(NAVGRAMS, Speed Letter, DoD letter)
4. Military Guard Mail--(on-base hand delivered messages)
5. Computer-mediated communications--(DDN, electronic mail service, local area networks)

Some costs associated with these systems that are easily quantifiable, i.e., phone bills, postal fees, average message cost, etc. Other costs are harder to quantify. Examples of these costs include:

1. Man hours for telephone use: waiting for an AUTOVON line, repeated redialing due to a busy signal, calling back when the other party is unavailable, etc. ("telephone tag").
2. Man hours required for record messages: drafting a message, routing for release authority, hand carrying/over-the-counter service at a message center, and over-the-counter/hand delivery at the receiving end. The same steps must be repeated for a message response.
3. Loss of effectiveness and efficiency: delay associated with (1) and (2) above, as well as the delay associated with the composition, transmission, receipt, and response time of a letter.

B. SYSTEMS COST EVALUATION PROCESS

The questions that must be asked when evaluating the Navy's communications costs are:

1. Are total communication costs too high for the value received?
2. Is the Navy allocating adequate resources for needed communications? If a message is not needed but is being produced, then the Navy is spending too much on this communication. If, however, the message is needed but not being being produced, the Navy is not spending enough. [Ref. 17 p. 236]

The Navy's objective since 1985 has been to reduce total record message traffic by 20 percent a year [Ref. 21]. This CNO directive was issued because the NTS/AUTODIN message delivery systems were operating at or near capacity, causing increasing delays in delivery, especially with low priority administrative messages. This problem of delay is greatly increased during an actual or simulated emergency. At these times commanders are directed that only messages that concern accomplishing a mission (operational) or safety of life are considered essential and require electronic transmission. The Navy has attacked this traffic problem using two approaches :

1. By directing that message drafters include the word "ADMIN" on any message that is administrative in nature. This allows "ADMIN" traffic to be removed from the fleet broadcast temporarily in favor of more time-sensitive information.

2. By establishing the Navy Mailed Message Program (NAVGRAM) and Speed Letter concepts.

Until now little has been done on a Navy-wide basis to compare the costs of these various communication systems, although some cost comparisons for commercial systems have been done. The Navy operates under very tight budgetary constraints, and must ensure that it gets the most "bang for the buck" possible from its communications. Thus, cost comparisons are essential.

C. TYPES OF COMMUNICATIONS COSTS

Written communication costs includes time spent deciding what to send and composing the message, and the resource cost of transmitting the message (both time and money). Face-to-face communication often involves travel, resulting in manhours wasted and high expense. Telephone communication has a cost associated by having to be sychronous, as well as the resource cost of transmission.

Additionally, in any medium, if a message uses a communications channel that is operating near capacity there may be the added cost of delay [Ref. 17: p. 112]. This added delay cost can easily be seen with the current delays that can be expected with the AUTOVON and AUTODIN systems. AUTOVON circuits are often busy causing an inordinate delay, especially during peak usage hours. When a circuit does become available one often finds the circuit on the other end is busy. With AUTOVON there is blocking at both ends of a transaction. With AUTODIN the delay depends on the priority attached to the message and whether the message is ADMIN or operational. As discussed in Chapter II, with message switching when the system nears capacity the queues can become quite long.

Because information costs, only a limited amount of information is used by any organization. So the methods used by the organization to collect, select, and transmit information are critically important determinants of its behavior [Ref. 17: p. 112]. Navy organizations are no different.

Five different approaches can be used to assess the Navy's communications systems and their costs.

1. The cost control approach, which is concerned with the direct cost of communications. Direct costs are the dollar and cents expenditures for communications equipment, materials, space, and labor. Job failure costs resulting from inadequate communications must also be evaluated.
2. The systems and procedures approach, which examines communications by systems and procedures, and is concerned with who initiates, who handles, who receives, and who is responsible for the communications in question. Also considered are how many messages were generated, how many transmitted, and for what purposes.
3. The media approach, which focuses on the different technological means, both hardware and software, by which communications are exchanged. The most efficient and effective use of the media is sought, and efforts are made to insure that procedures are compatible with the technology being used.
4. The human relations approach, which focuses on human factors involved in communication, including the wants and needs of the users.
5. The organizational communication approach, which determines what communication policies and practices do. Focus is on the organization's communications guidelines and how they relate to its administrative and operational policies, influence all forms of message delivery. Message communication then can be shaped to complement the complete organizational scheme. [Ref. 22: pp. 3-6]

The Navy's primary focus on cost control is in the areas of systems and procedures. As important as these approaches are because of bugetary constraints and command structures, more emphasis should be placed in the areas of media, human relations, and organizational communications.

D. ELECTRONIC MAIL--WHAT WILL IT COST?

1. Costs of Commercial Systems

The SITA network is a non-profit association of most of the world's airlines. It handles airline seat reservations and other messaging services. SITA is used by over 270 member airlines in over 1000 cities, with 198 telecommunications centers worldwide.

In 1984 its electronic mail system handled over seven billion messages at an operating cost of $136 million ($.02 per message). Cost figures include leasing of trunk lines and operating expense, including personnel. They do not include terminal costs, since these are fixed and non-recuring.

The average message length is short, approximately two lines of text. The system does not guarantee delivery of every message as DDN does. Yet $.02 per message is a significant savings over the cost of using conventional mail or long distance telephone service. [Ref. 23: p. 29]

The Digital Electronics Corporation conducted a study of 1000 users of their electronic mail system, DECmail, to determine what method of communication they would use if they did not have an electronic mail account. The unit cost for various communications media also was determined. Included in this cost were calculated average manhours, cost per manhour, materials used, etc. The cost of a single electronic mail message was used as a base factor of 100 percent for cost comparisions. The result of this study in shown in table 4.1. [Ref. 24: p.108]

Electronic mail has a considerable cost advantage over other methods when dealing with multiple addressees. Comparisions were made against the cheapest means of service; the cost advantage for electronic mail is even greater when compared to public telephone or Telex. Overall this study showed that if electronic mail were not used communication cost would be 30 percent higher. [Ref. 24: p. 109]

The cost savings proves even more significant when considering economies of scale. High economies of scale can be reached by simply increasing the message flow. The more these companies shifted their communications to electronic mail, the greater the overall savings.

Table 4.1

Communication media if electronic mail were not available

Internal memo	38%
Telephone	29%
Internal Telex	14%
Meeting	9%
Hand written note	7%
Nothing	3%

Cost comparison for communications media

Medium	Original	Copy
Electronic Mail	100%	23%
Memo	140%	29%
Telephone (internal)	80%	80%
Telex (internal)	120%	26%

2. Cost of Electronic Mail using DDN

DDN costs are based on a kilopacket (1000 packets) rate. One packet on DDN has 1224 bits of which 1008 bits are actual data, and the the rest are overhead. Current kilopacket rate (peak time) on DDN is $1.25.

One packet is equivalent to 1.575 lineblocks. A lineblock equals 80 characters or 640 bits. It therefore takes 27.9 packets to send one 44 lineblock message (an average message size) on DDN. The cost for a 44 lineblock message transmitted over DDN would be approximately $.04 at peak kilopacket rate. This rate does not include terminal or manpower cost.

3. Cost of AUTODIN Service

AUTODIN costs are based on cost per lineblock. The average cost per line block on AUTODIN runs approximately $.01, and the average message equals 44 lineblocks. The average transmission message cost on AUTODIN then is $.44. This rate does include the backbone and leased access lines but not terminal or manpower cost.

In a study done for the DCA in Janurary 1987, one AUTODIN Automatic Switching Center (ASC) handled 6,340,992 lineblocks or 4,058,190,080 bits (4,025,982 packets) in December 1986. The AUTODIN backbone charge was $21,960 for two 4800 baud circuits that month. The AUTODIN cost used per line block was $.00346.

If DDN had handled the same traffic the total cost would have been $1.25 X 4,025,982 = $5,032, with a monthly connection charge for a 9.6 kbs line of $1750, totaling $6782.48 that month. The savings for one month would be $15,177 for approximately a 70 percent cost reduction. [Ref. 25]

4. Postal Mail Costs

A cost study was conducted on United States Postal Service mail cost at the Naval Postgraduate School (NPS) between April 15, 1987 and January 11, 1988, This study focused on first class mail, which was determined to be the closest alternative to electronic mail. Also, first class mail is the only service offered by USPS that is used to send Navy Speed Letters and Navy mailed messages (NAVGRAMS).

First class mail accounted for approximately 85 percent of the total mail cost to the school during that period. First class mail is charged by weight: $.22 is charged for the first two ounces, and $.17 for every additional two ounces. This amount will be raised to $.25 for the first two ounces during 1988. During the period studied,the average cost to the school per first class transaction was $.59, including both letters and packages. This average cost was based on an average of 6,888 pieces per month at an average cost of $4065 a month. [Ref. 26]

A cost comparsion between electronic mail (DDN) and postal mail is very difficult. Some basic assumptions have been made in order to perform the comparison, including:

a. Postal Mail

* A first class letter is considered to be one page, and thus contains the equivalent of an average AUTODIN message (44 lineblocks of information).
* The cost of a single first class letter is assumed to be $.22

* A first class letter only has one addressee for each letter.
* Approximately 90 percent of first class mail are letters.

b. Electronic Mail

* A DDN mesage is assumed to contain 44 lineblocks of information.
* The cost of a single DDN message is $.04, including access cost (9.6 kps line) during peak times.
* With DDN the electronic message can have multiple addressees.
* Approximately 50 percent of all first class mail could be sent sent from NPS using DDN electronic mail This approximation is based on one estimate that up to 50 percent of first class mail is already being generated by computer in digital form [Ref. 23: p. 29].

5. Telephone Costs of Service

In FY 84 the DoD paid $1.3 billion for both long haul and local telephone service combined. Of this amount almost $800 million was for long haul service. The DoD also paid approximately $2 billion in equipment and manpower cost for telephone service that same year.

The average length of an AUTOVON call is approximately 5 minutes after the call is established. However, it has been shown that in the business world, that four out of five business calls fail to reach the intended party on the first try. A 20 percent success rate points to extreme inefficiency and waste with this medium. [Ref. 27: p.199]

In a case study conducted at the NPS of long distance telephone service for FY 87, NPS phone costs totaled $196,492, excluding AUTOVON. This study included only those charges for WATS and direct-dial long distance [Ref. 28]. Some assumptions must be made to compare telephone costs with electronic mail costs. For FY 90 through FY 93 DDN has established certain fixed charges that will be made for DDN use. For this study NPS was considered to have a dual-homed host (access to two separate PSNs) with an annual access fee of $18,000, an annual dedicated terminal fee of $3,600, and a dial-in access rate of $.075 per minute or $.375 per 5 minutes. Assuming 100,000 dial-in access calls per year (an extremely high number), the access charge would be $37,500 a year. Total DDN fees

would be $59,100. Even if transmission packet cost were included, the total would not equal the $137,392 required for direct dial and WATS long distance rates (excluding AUTOVON).

E. COST/BENEFIT SUMMARY

The above discussion comparing the relevant cost of several message delivery systems is summarized as follows.

1. Private industry has demonstrated significant cost savings utilizing electronic mail to the exclusion of telephone, Telex, mail, memo, etc.
2. When comparing AUTODIN and DDN cost, the equivalent message sent via DDN showed a 70 percent savings. Considering the extremly high volume of message traffic currently on AUTODIN, even if a small percentage of mesage taffic could go DDN, the impact on communication budgets would be substantial.
3. Comparing postal mail, telephone, and electronic mail (DDN) the cost savings again proved substantial. Electronic mail will likely never replace the mail and the voice telephone but it can be a cost saving alternative where available.

V. ELECTRONIC MAIL IMPLEMENTATION

The Navy presently lags behind the other military services in realizing the full potential of electronic mail, DDN, and local area networks (LANs). The Army, for example, has done a detailed evaluation of electronic mail as the eventual replacement for all unclassified narrative traffic that is currently carried on AUTODIN. The Navy may not require such a drastic step, but should consider implementing a service-wide electronic mail system in some form, for the transfer of informal messages and data.

There is an urgent need to upgrade, standardize, and make interoperable all data communications within DoD. Current Navy policies concerning electronic mail are discussed below. What is being done in the other services also is considered in regards to electronic mail and the eventual transition of data communications to the DDN.

A. STATUS OF NTS AND AUTODIN SYSTEM

The NTS and AUTODIN systems in use today utilize technology dating back to the 1960s and early 1970s, as well as outdated operational concepts. Many different types of communication equipment presently are used to provide basic record traffic services. These dedicated single function/single user systems should be replaced with an integrated common-user network that will provide for all communication services. Due to the manpower intensive mode of current operations, including over-the-counter service and maintenance expense of outdated technology, the Navy must face increasing communications cost in the near future unless changes are made.

Several studies have been done by the government and by independent contractors to determine what should be done to replace the current record communications concept. Most of these studies have resulted in the same conclusions: the current system is manpower intensive as well as outdated and expensive to maintain. Most of these studies also recommend some form of peer-to-peer

electronic messaging system (i.e., electronic mail) as the preferred replacement for the current DoD systems. [Ref. 29: p. 3]

These studies have not evaluated other means of deliverly systems, such as postal mail and the telephone system, against current record communications. Electronic mail can be viewed as a complimentary service rather than a replacement service, at least in the interim, for AUTODIN, postal mail, and the telephone. Many issues are involved in phasing in a robust electronic mail system. An examination of a possible future electronic mail/DDN architecture and a discussion of policies are appropriate, and are provided below.

B. STATUS OF NARRATIVE MESSAGE SERVICES

Formal narrative messages are typed on DD Form 173 and are hand delivered by the originators to Navy Telecommumications Centers (NTCCs) located at Navy installations. Distribution to the recipients is provided as an over-the-counter service. The manual delivery and administrative processing of messages at the originating NTCC and manual distribution at the receiving end result in considerable delays between the writer and the reader. The procedures used today are costly, manpower intensive, and inefficient when compared with the services and economies available with contemporary technology.

The Army recently studied the manpower requirements to operate and maintain its Telecommunications Control Centers and Standard Remote Terminals. Approximately 2600 personnel are required. In addition, approximately 730 personnel are required to staff the five ASCs and 11 Automated Multi-media Message Exchanges operated by the Army. By today's standards for automation these quantities were deemed unacceptable. Exact manning figures for the Navy's telecommunications centers are unavailable, but probably are similar.

C. STATUS ELECTRONIC MAIL POLICY

According to a memorandum from the Joint Chiefs of Staff in June 1985 [Ref. 12: P. 3], electronic mail can be considered as:

1. A computer to computer information system.

2. User controlled, funded and procured.
3. Either formal (official) or informal based on a command decision.
4. Limited to DoD protocols for interoperability.

Electronic mail is not considered by the Navy to be:

1. A service of the Defense Communication System.
2. Equated with an AUTODIN message. [Ref. 12: p.3]

A primary issue for the Navy is whether electronic mail should be treated as official (formal) or unofficial (informal) communication. The Navy's position at the present time is that electronic mail is not considered the equivalant of a naval message. However, no Navy position has been taken on whether electronic mail is equivalent to a letter (postal mail).

Letters can be formal or informal depending on who has the authority to sign, whether the letter has the offical designator attached (letterhead), and whether the letter is serialized (filed). Special coding can be appended to the drafted message (letter) so that only persons with access to a special signature code or personnel identification number can access and release the message. Electronic mail can also be serialized, signed, and given offical status. Electronic mail can also be formatted as either official or unofficial. The method of transmittal should not affect whether a message is official or unofficial. The envelope is the only difference. [Ref. 12]

Current electronic mail status in the Navy can best be summarized as follows:

* Electronic mail use is growing rapidly using the DDN addressing scheme.
* The Navy correspondence manual allows for message transmission via electronic media.
* NAVGRAM decision by SECNAV states that administrative messages can be sent through the postal service; transmission via electronic mail might be considered.
* An electronic mail prototype currently is being used by Naval Data Automation Command for offical business transactions with its field activities Navy Regional Data Automation

Command Stations, providing acceptable message response times.

* As of January 1988 a Standard Navy Distribution List is accessible via DDN with addresses of commands who will accept electronic mail. [Ref. 12]

D. BASE INFORMATION TRANSFER SYSTEM

The Base Information Transfer System (BITS) is a conceptual structure for guiding the development of Navy data communications at Navy installations. BITS is a component of the Navy Data Communications Control Architecture which has overall data communications responsibility for the Navy's inter-base, intra-base, ship-to-shore, and shore-to-ship communication.

BITS, as an ongoing development process, is a response to several problems with the current Navy data communication system:

1. Lack of communications interoperabilty, both local and long haul.
2. Inefficient interface to and utilization of long-haul communications.
3. Lack of centralized direction and resource planning and management. [Ref. 30: p. xi]

1. Intrabase and Interbase Communications

BITS provides for intrabase (on-base) electronic data communication. This usually is provided by the switched telephone system, using a phone modem, where low data rates and small volumes of traffic are involved. Where high data rates and large volumes of traffic are involved dedicated lines or local area networks usually will be used. Base local area networks should interoperate and a user on one network should be able to exchange electronic mail, exchange data bases, and access data files with a user on a different local network.

BITS also provides for interbase (off-base) electronic data communications. These usually are provided through AUTODIN and DDN. Currently, if the information is a message, transmission is provided through a NTCC, with direct connection to the AUTODIN network. As mentioned earlier, much of the interfacing between user

and NTCC is still manual. If the information consists of data and both bases are DDN capable, then DDN is the means of transmission. [Ref. 30]

2. Interoperability

Interoperability refers to how well different systems work with one another. Serious interoperability problems presently exist in Navy communications. In the past the navy has attacked this problem through individual local interface solutions, rather than taking a standardized Navy-wide approach. The standardization required is not in "hardware" or even transmission medium, but rather in the area of "software" and communication protocols (SMTP, TELNET, FTP, etc.). Under The BITS initiative, interoperability between local area networks and long-haul networks is being addressed and solutions proposed.

E. LOCAL AREA NETWORKS

LANS are a critical component of the BITS initiative. Characteristics of local area networks include high data rates (several million bits per second), short tranmission distances, and low error rates. Software or hardware upgrades and replacements usually can be made with little impact on other devices on the network. Currently, Navy local area networks provide connection capability and connectivity, but do not guarantee interoperability. Interoperability requires application compatibility, which may or may not be provided by the network. [Ref. 31: p. 64]

1. Evolution of Local Area Networks

Local area networks have evolved from specific systems and applications to general purpose systems that provide interconection to a variety of terminals and computers. Connected elements usually are within a defined geographical area where the users are in close physical proximity (usually less than one mile). Personal computer networks are a recent local network development. They are a logical outgrowth of office automation networks which are dependent on personal computers for word processing applications. Personal computer networks are viewed as a low cost networking solution.

Electronic mail and electronic file transfer are typical application features.[Ref. 31: p.66]

2. Standards

Recent local area network development has concentrated on standardizing protocols based on the International Standards Organization (ISO) Open Systems Interconnection (OSI) model. A standard for the new personal computer networks is beginning to emerge. Parts of the OSI guidelines are included in that network system design. standard

F. GATEWAYS BETWEEN AUTODIN AND DDN

Before electronic mail receives favorable consideration for inclusion into the Navy's future communications scheme, some way to interface with the current methods for electronic message transfer must be found. The U.S. Army Information Systems Command System Engineering Office has proposed and field tested a gateway between AUTODIN and DDN for message traffic. This gateway is called the AUTODIN Mail Server (AMS). It is considered by the Army to be the ideal method of making the transition from AUTODIN to an electronic mail-oriented world. Figure 5.1 illustrate that AMS gateway [from Ref. 32]

Another alternative for achieving electronic mail in the Navy is to fully utilize the DDN without a transitional gateway system. The header and other requirements forf Navy message communication would be programed into the DDN. Consideration of this alternative is beyond the scope of this thesis.

Users on the electronic mail system are able to originate messages that can be delivered via DDN, AUTODIN, or both. The users have only to address all messages as they would for electronic mail messages and the interface will provide the correct routing. Users on the electronic mail system will see only electronic mail message format; all conversion to AUTODIN JANAP 128 format is completely transparent. [Ref. 32 p.12] The actual AUTODIN mail server code resides on the electronic mail host where it serves as a logical extension of the tranfer software.

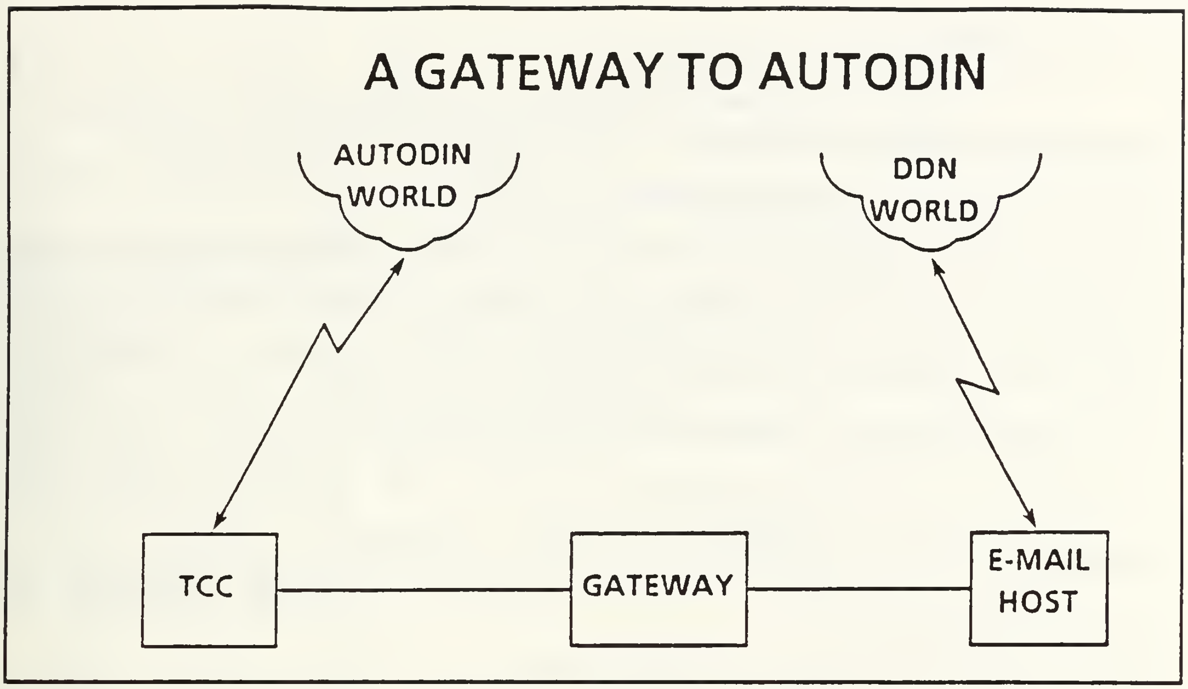

Figure 5.1 AUTODIN Mail Server Gateway

The initial test and evaluation phase of the AUTODIN mail server is scheduled for early 1988.

1. AUTODIN to Electronic Mail Transmission

The Army's first phase of the its AUTODIN mail server will not have Plain Language Address (PLA)-to-Routing Indicator (RI) capability. However, This will be available on personal computers and will enable exchange of JANAP 128 messages in both directions. The mail server must first be certified for an AUTODIN Automatic Switching Center (ASC) before this capability can be fully realized. An AUTODIN interface device will provide a "splitting" function based on message security to assure that only unclassified narrative messages are sent to the mail server. After PLA/RI has been developed for a personal computer and the mail server, the AUTODIN interface device can provide connection directly to AUTODIN. Connection through a NAVCOMPARS/LDMX is another option.

2. Transition Strategy

Primary concern during the transitional period is to automate the distribution of unclassified administrative traffic to the user, by utilizing electronic mail technology.

The AUTODIN-to-electronic mail gateway software residing on the unclassified messaging host will provide most of the services offered by the existing AUTODIN/NTCC system. It will provide format conversion from the electronic mail format input by the user to the appropriate JANAP 128 or ACP 126 format for transmission through the AUTODIN network. It will do the same conversion on the receive side. Unclassified, routine, narrative messages will be delivered immediately to the user mail box on the electronic mail host. [Ref. 32: p19]

The strategic systems involved in this transition plan are the AUTODIN Automatic Switching Centers (ASCs) and the Navy's Communications Processing and Routing System (NAVCOMPARS) and Local Digital Message Exchange (LDMX). The record traffic services of concern include data transfer and narrative text messages. The purpose is to enhance communications for the duration of this century and allow for easy, full integration into DDN.

It is estimated that by the early 1990s the Inter-Service/Agency Automated Message Processing Exchange (I-S/A AMPE) system will be in place. The I-S/A AMPE will utilize the DDN for long haul transmission and will provide connectivity with current AUTODIN Switching Centers (ASCs). I-S/A AMPE eventually will completely replace the ASCs and the Navy's current Automatic Message Processing Exchange, the Local Digital Message Exchange (LDMX). The cross network connectivity provided by the I-S/A AMPE could allow electronic mail users to send and receive messages to and from users who only have access to AUTODIN. However, there is no provision currently in the I-S/A AMPE plan for development of an AUTODIN-to-DDN electronic mail gateway. [Ref. 29: p. 3]

It often may be necessary to enter a message into the NTS in accepted ACP 126 or JANAP 128 format. This will be possible directly through a NTCC, or an existing gateway between AUTODIN

and DDN Similiarly, there must be a way to convert electronic mail messages to NTS/AUTODIN message formats

A Navy mail host will have to use protocol standards which allow free interface with any existing mail host that uses the standard DDN protocols (X.25, TCP/IP, FTP, Telnet, and SMTP). The current NTS/AUTODIN operation will continue unaffected except for a decrease in the unclassified administrative traffic that could migrate to the electronic mail system. The most vital link in this transition will be actually putting The electronic mail system in place. [Ref. 29: p.34]

G. PRIMARY OBJECTIVES FOR DEVELOPING AN ELECTRONIC MAIL INTERFACE

The primary objective for developing such an AUTODIN-to-DDN gateway is to provide a single integrated messaging service for all users. This concept may be too ambitious from the Navy's point of view considering the fundamental differences in operational requirements for the two systems. However, utilization of some form of electronic mail service on DDN may reduce some of the burden on the NTS and AUTODIN. The Navy's strategic objectives should include the following:

1. Maintain current communications capability with NTS and AUTODIN, while creating a functional equivalent on DDN.
2. Begin to migrate administrative traffic from NTS and AUTODIN to DDN and an electronic mail environment in order to improve delivery service, decrease costs, and reduce manpower requirements. Improvements should include increased speed of service and efficiency, direct distribution to users, automated assistance, and worldwide connectivity and interoperability.
3. Develop a comprehensive strategic plan for evolutionary development.
4. Identify the technical risks in order to minimize cost impact.
5. Ensure compatible software development in a multiple hardware vendor enviroment.
6. Coordinate with the other military services.

H. SUMMARY

The developmental process for implementing electronic mail must be evolutionary and not revolutionary. The Navy already has the basic management structure in place as a result of the BITS initiative, to ensure a smooth transistion to electronic mail. With the recent developments in local area networks and DDNs expansion, every base could become an integrated member of an electronic mail network. The Army is already planning for just such a development. As AUTODIN is phased out in favor of DDN, users will become intimately aquainted with DDN use. All message traffic will eventually migrate to DDN.

VI. CONCLUSION AND RECOMENDATIONS

A. CONCLUSION

New ideas are fostered through the interaction of needs and technology. Innovation that fills a need is more sucessful than innovation simply intended to exploit a new technology. Electronic mail has been very sucessful in the commercial world because it was developed to fill a need, and was only secondarily developed to exploit the available technology. The technology did not create the perceived need, and vendors primarily provide a service to meet that need.

The Navy is currently experiencing a communication problem with its outdated systems due to increasing costs and systems saturation. First class postal mail costs are expected to rise approximately 12 percent in 1988. Telephone rates are also increasing. AUTODIN and AUTOVON circuits are saturated, causing inordinate delays in communication.

It is technically feasible for the Navy to implement an electronic mail system Navy-wide for informal communications. Common interest and compatability of equipment and services are necessary to achieve the full potential of that communication media [Ref. 1: p. 14]. Electronic mail has the ability to accelerate the flow of information and at the same time increase the data processing capability to ease the burden of possible information overload.

If users choose not to use electronic mail or its use is not mandated by proper authority, it may lose its value and effectiveness. Electronic mail can have a profound effect on how Navy personnel relate to each other, but only if the decision for its use is made at the highest level of authority. Making the decision to purchase the necessary hardware and software is not enough. Users will need training and educating, because in the world of communications to be the only person using a means of communication is meaningless.

B. RECOMMENDATIONS

The following recomendations flow logically from information reviewed for this study.

1. DDN is a proven technology and represents the future of all DoD data communications. It is an ideal vehicle for expanding the use of electronic mail for informal communications. A detailed study on how to implement electronic mail on a Navy-wide basis should be considered by cognizant authority.
2. Many human factors are involved while implementing a new communication scheme such as electronic mail. These factors have not all been resolved. Development of a truly user friendly electronic mail system is necessary. The human interface will be vital if electronic mail is to be accepted.
3. A detailed cost analysis of what the Navy is spending on informal communications such as telephone, postal mail, etc., is urgently needed even though such comparisions are not easy to draw.
4. A strategic electronic mail implementation plan should be developed for informal Naval communications.

APPENDIX

GLOSSARY OF ACRONYMS

ACRONYM	DEFINITION
ACP 126	Allied Communication Publication "Communication Instructions - Teletypewriter Procedure"
ADMIN	Administrative messages
ARPANET	Advanced Research Projects Agency Network
ASC	Automatic switching Center
AUTODIN	Automatic Digital Information Network
AUTOVON	Automatic Voice Network
BAUD	Number of times per second that a transmitted signal changes its value
DCA	Defense Communications Agency
DDN	Defense Data Network
DoD	Department of Defense
DoN	Department of the Navy
FTP	File Transfer Protocol
FY	Fiscal Year
ISO	International Standards Organization
JANAP 128	Joint, Army, Navy, Airforce Publication "Automatic Digital Network (AUTODIN) Operating Procedures"
Kilopacket	1000 packets of data
LAN	Local Area Network
LDMX	Local Digital Message Exchange
NAVCOMPARS	Naval Communications Processing and Routing
NAVGRAM	Navy mailed message program
NTCC	Naval Telecommunications Center
NTS	Naval Telecommunications System
PSN	Packet Switching Node
SMTP	Simple Mail Transfer Protocol system

TAC	Terminal Access Controller
TCP/IP	Transmission Control Protocol/Internet Protocol
Telnet	Telecommunications network protocol
WATS	Wide Area Telephone Service
X.25	Standard network access protocol

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c.1 Implementation of electronic mail for informal Naval communications.